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Actual preferences for EV households in Denmark and Sweden

Anders Fjendbo Jensen*, Sonja Haustein**, Elisabetta Cherchi***, Mikkel Thorhauge*

*Division of Transport Modeling, DTU Management Engineering, Technical University of Denmark
** Division of Technology and Innovation Management, DTU Management Engineering, Technical University of Denmark
***Transport Operations Research Group, School of Civil Engineering and Geoscience, Newcastle University

Battery electric vehicles (EVs) have received vast attention in the recent decade, especially due to their potential environmental benefits. The car industry has invested huge amounts in the battery electric vehicle technology, leading to a much larger selection of car models with better comfort, driving range and options for recharging the batteries. Several studies have indicated that a great share of car households would now be able to maintain their current mobility patterns with only a minor level of adaption (Christensen 2011; Pearre et al. 2011; Greaves et al. 2014). Still, the driving range of a fully recharged EV is of great importance to the potential users (Jensen et al. 2013; Dimitropoulos et al. 2013; Mabit & Fosgerau 2011; Franke & Krems 2013), but as the battery capacity of the EVs continue to increase, the mobility constraints related to former EV models will most probably be reduced. Thus, the EV alternative has changed from being a product for a very small group of enthusiasts to being an actual car alternative for a common household and knowledge about which type of households would be interested in EVs is extremely valuable for both industry and policy makers. However, as the EV market is still quite immature in most countries, lack of data on EV users is a common problem for researchers. Data on EV purchase and use have thus often been collected by means of data from intentional statements (see e.g. Bühler et al. 2014), stated preferences (see e.g. Bunch et al. 1993; Hidrue et al. 2011; Jensen et al. 2014) and EV vehicle trials (Golob & Gould 1998; Franke & Krems 2013; Jensen et al. 2014). While such studies have provided important insight into various areas of the EV market, the fact that the results are not based on actual behaviour means that they are subject to a high degree of uncertainty. Being the global EV market forerunner, Norway has a better foundation for studying the EV market based on actual EV owners. On these grounds, Klöckner et al. (2013), studied differences in car use between EV and conventional vehicle (CV) users. Also in Norway, Mersky et al. (2016) and Bjerkan et al. (2016) both studied the effect of policy incentives on EV purchase.

Compared to these existing studies, we contribute to the literature with a more advanced model to study the EV market and we focus on the market in Denmark and Sweden. In particular, we use revealed preference information to investigate how household characteristics, attitudes, norms, perceived barriers and perceived functional attributes of the EVs affect the probability of being an EV household. The data utilized in this study was collected in connection with the EU project GREAT, which aims to reduce fossil emissions by improving supply for alternative-fuelled vehicles in northern Europe. Besides detailed individual and household characteristics from a sample of both EV and CV household users, the data contains detailed information on individual determinants of EV adaption based on the Theory of Planned Behaviour (Ajzen 1991).

Data were collected through an online survey in Sweden and Denmark. The Swedish study was distributed through different channels including the intranet of regions Skåne and Västra Götaland,

different newletters and EV related facebook groups. In Denmark, EV users were contacted via the infrastructure provider E.ON, while the CV users were contacted through the online panel of the market research institute EPINION. In total 1364 observations are available for Denmark and 1288 for Sweden. Descriptive statistics of the sample show that EV respondents were to a much higher extend male, had a higher household income and higher education level and were more often self-employed, lived less often alone and more often had children compared to CV users. Comparing Tesla users to other EV users, we found that Tesla users perceived less functional barriers in terms of EV usage, had more positive affective attitudes related to driving an EV and felt to a higher degree supported by relevant others to use/buy an EV (subjective norm). Interestingly, they did not report more positive symbolic attitudes in relation to their EV ownership.

We modelled the probability of being an EV household with an advanced discrete choice model, taking both household characteristic and the latent determinants of EV adoption into account. A preliminary hybrid choice model with a latent variable for perceived barriers and most relevant household characteristics is presented below for the Danish sample.

	Value	**Robust t-test**	**p-value**
Choice Model			
Alternative Specific Constant, EV	5.2	7.86	0
Number of adults in household	-0.167	-1.75	0.08
Number of children in household	-0.12	-1.24	0.21
Potential access to homecharging dummy	1.44	7.92	0
Household income, DKK	0.402	7.62	0
Degree of percieved barriers	-1.6	-11.83	0
Female dummy	-2	-9.15	0
Latent Variable Model, Structural model			
Intersect	4.8	45.92	0
Standard deviation of error term	0.0227	0.9	0.37
Number of adults in household	-0.0652	-1.95	0.05
Number of children in household	-0.0649	-1.96	0.05
Potential access to homecharging dummy	-0.466	-7.1	0
Household income, DKK	-0.0896	-5.27	0
Latent Variable Model, Measurement equation			
Indicator 1, standard deviation	-0.445	-11.48	0
Indicator 2, intercept	0.568	6	0
Indicator 2, attitude parameter	0.885	37.64	0
Indicator 2, standard deviation	-0.462	-11.78	0
Indicator 3, intercept	2.42	19.86	0
Indicator 3, attitude parameter	0.541	18.74	0
Indicator 3, standard deviation	-0.214	-10.06	0
Indicator 4, intercept	0.449	4.37	0
Indicator 4, attitude parameter	0.907	34.23	0
Indicator 4, standard deviation	-0.324	-9.42	0

Indicator 5, intercept	1.66	13.41	0
Indicator 5, attitude parameter	0.715	23.95	0
Indicator 5, standard deviation	-0.183	-7.51	0

The most relevant variables in the choice model are highly significant and with the expected sign. EV households are more likely to have a higher income and have access to a private parking place where home charging can be installed. Furthermore, these results indicate that EV owners are more likely men, which contradicts with previous studies based on stated preferences (Jensen et al. 2013; Glerum et al. 2013). Finally, the results indicate that EV ownership is related to a lower degree of perceived barriers related to EV use. Looking further into the structural model, it is seen that especially potential access to homecharging and income relates to a lower perceived barrier related to EV use, which is in line with our expectations.

This study will further advance by testing all relevant household characteristics and latent variables including subjective and personal norm, symbolic and affective attitudes and lifestyle characteristics. Besides testing different specifications of hybrid choice models, a latent class model based on the latent constructs will be tested. In order to test differences across Denmark and Sweden, the model will be estimated jointly on the two datasets taking possible scaling differences into account.

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